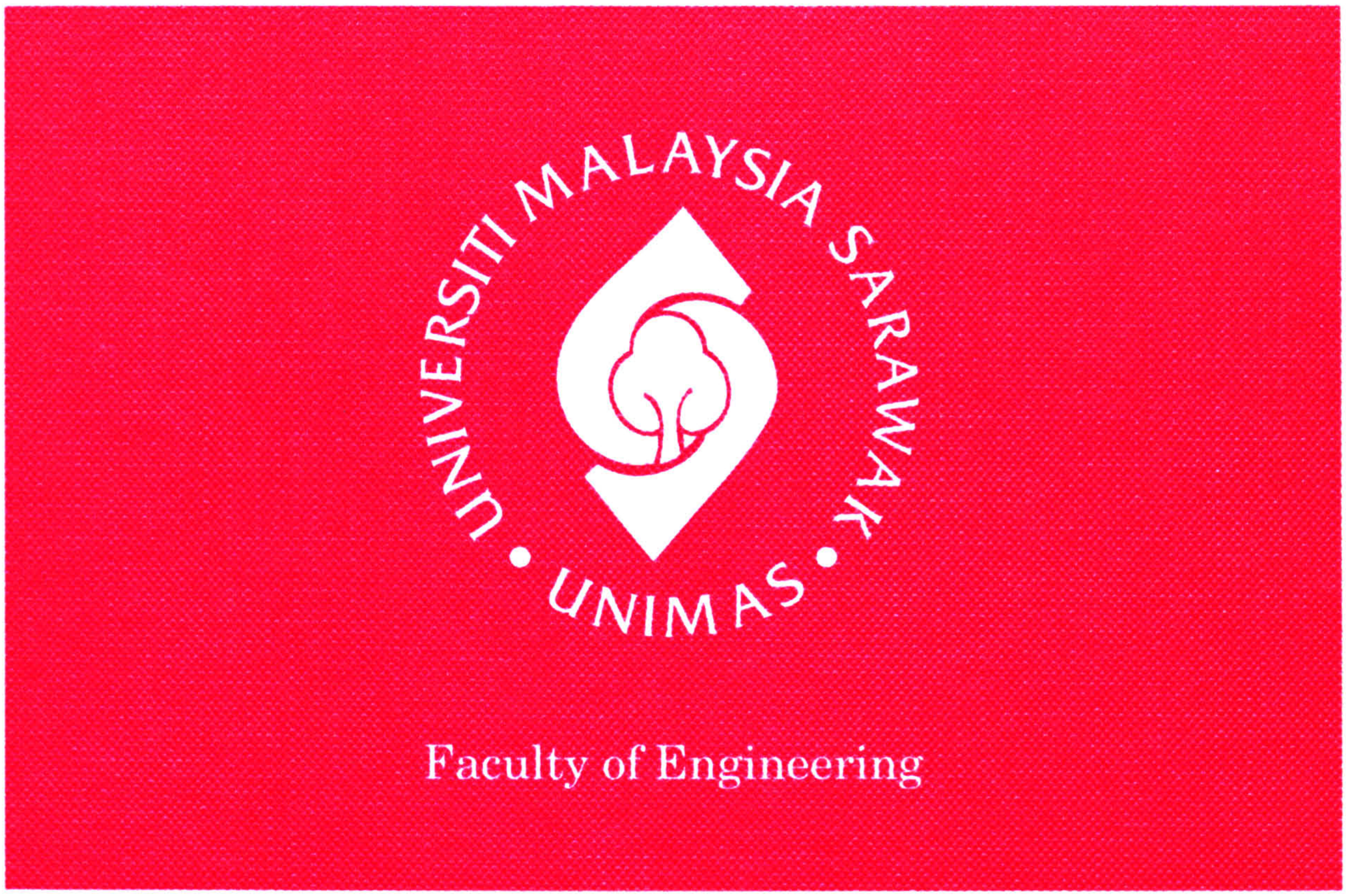


# PAVEMENT EVALUATION: AN OVERVIEW OF THE POTENTIAL IMPACTS OF CLIMATE CHANGE ON ROAD PAVEMENTS

Teo Hua Wee

Bachelor of Engineering with Honours
(Civil Engineering)
2009

**UNIVERSITI MALAYSIA SARAWAK**

R13a

**BORANG PENGESAHAN STATUS TESIS**

Judul: **PAVEMENT EVALUATION: AN OVERVIEW OF THE POTENTIAL IMPACTS OF CLIMATE CHANGE ON ROAD PAVEMENTS**

**SESI PENGAJIAN: 2008/2009**

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Matrix Number : 15414

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Encik Ron Aldrino Chan

Date

Project Supervisor

# DEDICATION

To my beloved father and mother…

To my loving siblings…

To my respectful supervisor…

To my fellow course mates…

# ACKNOWLEDGEMENT

First of all, I would like to thank my family for their utmost support and encouragement during the period of this thesis. I would also like to express my deepest gratitude to my supervisor, Mr Ron Aldrino Chan. Without his patience, guidance and supervision, this thesis would not have been completed on time. Your invaluable support will always be remembered. In addition, I also like to express my gratitude to all the government and private agencies who have assisted in making this thesis possible, in particular Jabatan Kerja Raya (JKR), Drainage and Irrigation Department (DID), Malaysian Meteorological Department (MMD), Jurutera Jasa (Sarawak) Sdn. Bhd., Jurutera Minsar Consult Sdn. Bhd., Konsultant Timur, CMS Roads and Pavement Tech Sdn. Bhd. Not forgetting my friends Ezra Mohd Zen, Wee Sing Yi and others who constantly encourage, support and inspire me throughout the period of this thesis. Last but not least, a special thanks to Teoh Huey Ming for your love and care, will forever be remembered.

# ABSTRAK

*Projek ini adalah bertujuan untuk melaksanakan satu taksiran awal pada kesan kesan perubahan iklim pada turapan jalan. Kod-kod semasa dan piawaian yang digunakan dalam rekabentuk turapan dan pembinaan masih menyerupai kod-kod 20 tahun dahulu. Kod-kod dan piawaian ini jarang dikemaskinikan dari semasa ke sesama untuk mencerminkan potensi implikasi bagi perubahan iklim. Oleh itu, terdapat satu keperluan untuk menyediakan satu kerangka umum untuk analisa kepentingan perubahan iklim pada kadar kemerosotan terhadap jalan. Faktor iklim yang diggunakan dalam analisis tertumpu kepada suhu udara permukaan, hujan dan angin. Pemuatan lalu lintas merupakan satu faktor tambahan yang termasuk dalam analisis ini bagi menganalisis potensi impak apabila ia berinteraksi dengan keadaan iklim. Hasil analisis itu menunjukkan peningkatan dalam penimbulan masalah dan mempercepat kadar kemerosotan pada turapan jalan. Oleh itu, terdapat satu keperluan untuk menjalankan perkembangan lanjut bagi rangka kerja berkaitan untuk meningkatkan ketepatan dan keyakinan bagi keputusan yang didapati. Oleh itu, ia mungkin satu rujukan penting dalam memperbaharui kod-kod dan piawaian semasa untuk kejuruteraan reka bentuk selain rekaan-rekaan jalan, dengan tujuan mencerminkan implikasi perubahan iklim terhadap ia.*

# ABSTRACT

This project is an attempt to conduct a preliminary assessment on the impact of climate change effect on road pavement. The current codes and standards used in pavement design and construction are similar to the one used 20 years back. These codes and standards are not updated regularly to reflect the potential implication of climate change. Therefore, there is a need for a clear assessment and strategy to analyze the significance of climate changes on the rate of pavement deterioration. The climate parameters used in the analysis are mainly the surface air temperature, rainfall and wind. Traffic loading is an additional parameter to analyze the possible impacts when it is combined with climate condition factors. The result of the analysis shows that the reoccurrence of arising problems may be increased and the rate of deterioration may be accelerated on road pavement. Therefore, there is a necessity to conduct further development of the assessment to increase the accuracy and confidence of the results. Thus, it may be an important reference in improving the current codes and standards for engineering designs besides pavement designs, in order to reflect the implication of climate changes.

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| | | |
|---|---|---|
| CBR | - | California Bearing Ratio |
| DID | - | Drainage and Irrigation Department |
| GCM | - | Global Climate Models |
| IKRAM | - | Institut Kerja Raya Malaysia |
| IPCC | - | Intergovernmental Panel on Climate Change |
| MMD | - | Malaysian Meteorological Department |
| TAR | - | Third Assessment Report |
| UNFCCC | - | United Nations Framework Convention on Climate Change |
| UNIMAS | - | University Malaysia Sarawak |

# CHAPTER 1

# INTRODUCTION

## 1.1 Background Overview

The world is currently facing severe environmental issues and climate change is one of the issues in resultant of the greenhouse effect. Studies and analysis on climate changes have been done all over the world from time to time to better understand the current environmental conditions of the surrounding while remedial actions are taken to prevent further deteriorations, enabling continuance of the world's development and providing better living environment for future generations.

According to IPCC (2007), global surface temperature over the past 100 years (1906-2005) has risen by 0.74°C, larger than the corresponding temperature rise for 1901-2000 given in the Third Assessment Report (TAR), 2001 of 0.6°C, concluding that the warming over the last 50 years is nearly twice that for the last 100 years.

While international bodies are analyzing the climate change, the Malaysian Meteorological Department (MMD) has played their role in

estimating the climate changes of the country. Forecast have been made on climate modeling using 14 GCM's (Global Climate Models) which shows that Malaysia could experience temperature changes from 0.7 to 2.6 degree Celsius and precipitation changes ranging from -30% to 30% by the year 2100 (Malaysian Meteorology Department 2007).

On the other hand, road deteriorations has been an ongoing issue in the country and environment is the main factor in resulting road defects such as cracking and surface deformations.

In relation to the global climate change, raises the question whether the climate changes would significantly accelerate the road deteriorations in the country and whether the current road construction standards are still applicable to adapt the climate changes.

This thesis studies the estimated climate change associated with different weather parameters in relation to the rate of road deteriorations in the country.

## 1.2 Problem Definition

Road pavements will be considered as a failure whenever its intended purpose of providing a safe and comfortable riding experience to road users is no longer applicable. The failure of road pavements is easy to be identified because it triggers the users' awareness of the increase in their vehicle

operating cost and time wastage. The riding quality is therefore no longer acceptable for private cars and commercial vehicles.

The predominant failure occurred on road pavements in the country can be classified into fractures, distortions and disintegrations (IKRAM 1994). Pavement deteriorations have always been an inconvenient for Kuching road users and the maintenance work carried out are still insufficient to successfully overcome the problem of pavement deteriorations.

Moreover, there has been a dramatic climate change in recent years, all over the world and our country is experiencing the changes itself. The atmospheric temperature is getting higher over time and abnormal rainfalls are occurring over the country as some states are facing serious droughts while other states have floods.

Figure 1.1 illustrates the annual maximum temperature trend for Sarawak since 1969. From the graph, the maximum temperature has a noticeable trend of increase over the years, providing a solid proof that temperatures are rising gradually over these years.

However, Figure 1.2 illustrates the annual rainfall anomaly for Sarawak since 1951. From the graph, the unsteady trend of precipitations since the mid-90s shows the abnormal precipitation occurring in these years and the trend of precipitation is affected by the climate changes as well.

This scenario may develop into a major factor in resulting pavement failures in the country. Therefore, a proper analysis is required to study these potential factors which may hasten pavement failures in order to reveal a precise solution to improve the existing roads and future road constructions, increasing the lifespan of road pavement for now and then.

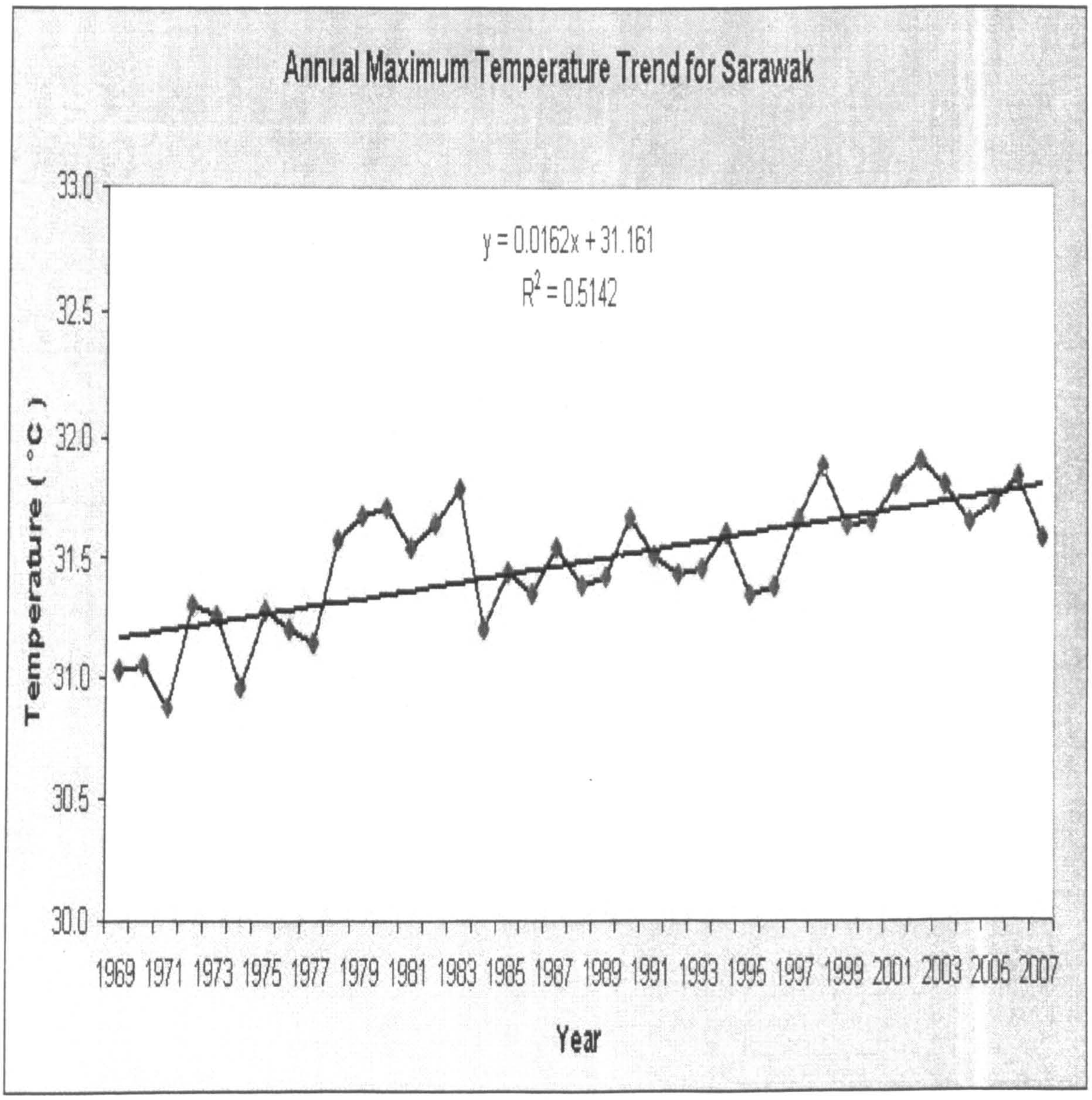


Figure 1.1: Annual Maximum Temperature Trend for Sarawak (Source from MMD)

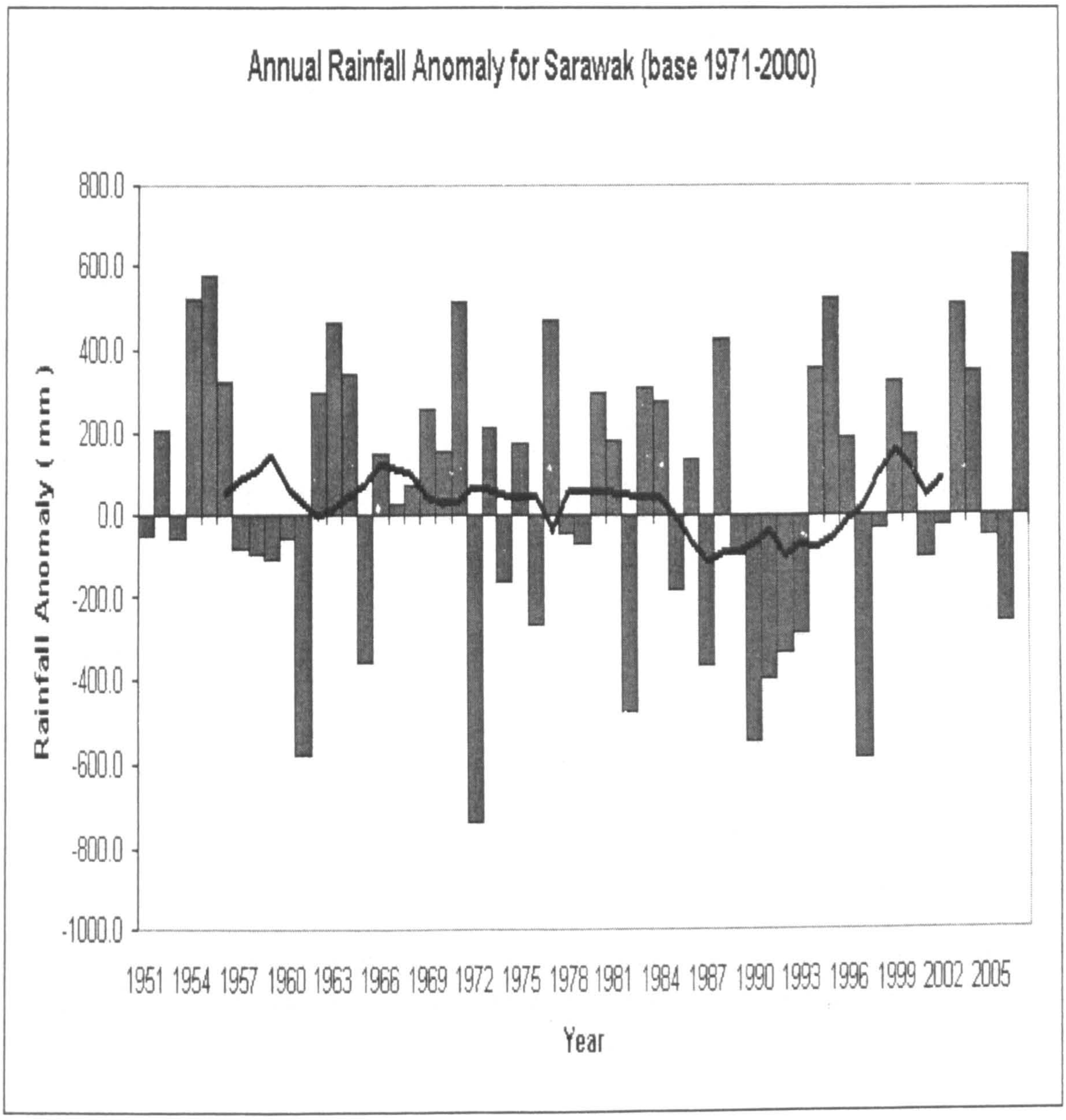


Figure 1.2: Annual Rainfall Anomaly for Sarawak (Source from MMD)

## 1.3 Objectives

i. To evaluate the impact of climate factors such as atmospheric temperature, rainfall and others on road deterioration.

ii. To compile and analyze the potential impact as well as to proposed preliminary mitigation plans.

## 1.4 Scope of Study

i. The scope of project focused mainly on desktop study of the current climate change impact on the existing roads particularly at Kuching-Samarahan area.

ii. Interviews with relevant agencies will be conducted to obtain further clarification on these impacts and its mitigation processes

iii. Collection of relevant data from local agencies such as JKR, DID, MMD, engineering firms and any related agencies.

## 1.5 Thesis Structure

This thesis is a compilation of five chapters in the following order: Chapter 1: Introduction, Chapter 2: Literature Review, Chapter 3: Methodology.

In Chapter 1, several sub-topics are being divided where there is an introduction to the topic of the whole thesis, objectives in producing this thesis, the scope of study and the thesis structure of the thesis

In Chapter 2, the content reviews the fundamental details on the road structures and the potential road failures. The current climate status which is being experienced globally and the effects on the climate changes are written in this chapter as well.

In Chapter 3, methods in conducting and achieving the objectives of this thesis are clearly explained.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 The Pavement

The pavement is the structure which separates the tires of vehicles from the underlying foundation material. Generally, it distributes wheel loads over an area so that the bearing capacity of sub-grade is not exceeded (JKR 1998). Pavements are constructed in multilayer over soil with comparatively weak materials beneath and increasingly stronger ones above.

The pavements are classified as flexible or rigid. The flexible pavements are called "flexible" since the total pavement structure "bends" or "deflects" due to traffic loads, it is generally composed of several layers of materials with bituminous surfacing which can accommodate this "flexing"(Hawaii Asphalt Pavement Industry 2003).

However, rigid pavements are called "rigid" because they are substantially stiffer than flexible pavements due to Portland Cement Concrete's high stiffness. In Malaysia, flexible pavements are major used as the country's road network to sustain the high traffic volume.

## 2.2 The Flexible Pavement Components and Materials

The flexible pavement is divided into layered structure consisting of surfacing, road base, sub-base and the surface overlying the earth ground or referred to as sub-grade. Figure 2.1 illustrates the cross section of a flexible pavement.

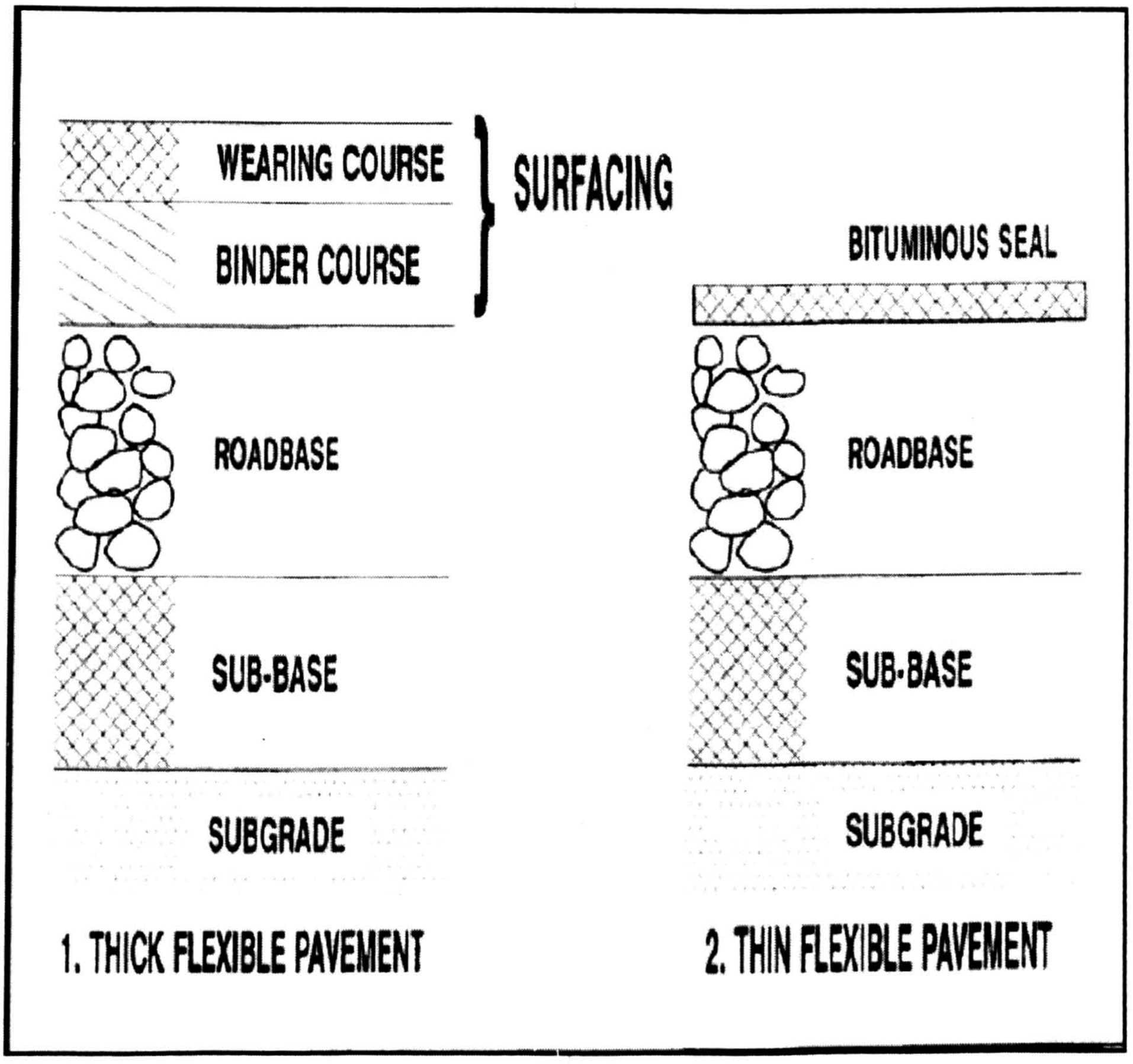


Figure 2.1 Cross Section of a Typical Flexible Pavement

### 2.2.1 Surfacing

The surfacing is the upper layer of the pavement which is in contact with traffic loads and normally contains the highest quality materials. In accordance to Institut Kerja Raya Malaysia (IKRAM), the road surfacing should fulfil the following requirements:

- To provide an even, non-skidding and good riding quality surface.
- To resist wear and shearing stress imposed by traffic.
- To prevent water from penetrating into underlying pavement layers.
- To be capable of surviving a large number of repeated loading without distress
- To withstand adverse environmental conditions

By referring to Figure 2.1, the form of bituminous surfacing commonly used can either be thick or thin.

Thick bituminous surfacing normally consists of crushed mixed aggregates, bitumen and filler and the most common types of plant mixed surfacing in Malaysia are asphaltic concrete or bituminous macadam, however the currently constructed thin surfacing are surface dressings and slurry seals (IKRAM 1994).

Thick bituminous surfacing protects the pavement from water seeping down beneath the structure and provides additional strength to the pavement.